Experimental evaluation of electricity output and crop growing potential in an agrivoltaic farm in the desert

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An experiment was carried out in an existing solar field to assess the potential of agrivoltaics in the Negev Desert of southern Israel to increase the yield of the PV panels and to demonstrate the viability of growing cash crops on the site.

The goal of the research was to answer two questions:

• Solar photovoltaic panels experience very high temperature in the summer months, which results in efficiency reductions. What is the effect on panel temperature and electricity output of adding irrigated vegetation to an exposed desert soil?

• What is the economic potential of a cash crop planted in a solar field in a desert environment?

The study was conducted in the summer months (June through October 2020) in an existing solar field operated by EDF Renewables, located near the town of Mashabei Sadeh. Three test sites (each 0.22 hectares in area) were chosen within the PV facility (see Figure 1): one control plot with standard PV facility maintenance (minimizing plant growth), and two other plots planted with different plant species: Lemon geranium (Pelargonium graveolens) for agricultural purposes and Australian viola (Dichondra) as a groundcover which does not require intensive care. The ground was plowed before adding compost and planting (see Figure 2). Measurements taken included global solar radiation, radiation reflected and emitted from the ground, net radiation, wind speed and direction, PV panel temperature, electric current and voltage. Differences in electricity generation between the plots were measured and the effect of microclimatic modifications was analyzed.

Panel temperature in the vegetated plots was lower during daylight hours by an average of 1.0-2.2°C, resulting in an increase in electricity of approximately 1%. The maximum improvement was observed in the Dichondra plots during the hottest hours of the day, with cooling up to 3.5 °C (See Figure 4) and an increase of electricity production of up to 1.6%. Furthermore, it was observed that vegetation planted between rows of panels was more effective in improving electricity production than vegetation directly below the panels (see difference in sun vs. shade in Figure 3). This is explained primarily by the reduction of long wave radiation emission and solar radiation reflected from the ground between rows, as well as differences in air temperature.

From an agricultural standpoint, plant yields (biomass) were greatest in the sunny areas between the panel rows (0.51 ton/hectare), whereas areas directly underneath the panels produced only 50% of that yield. Because the rows between panels are not only more productive but also are more accessible for cultivation, they are the preferred location for cash crops. Shaded areas beneath the panels may be planted with low-maintenance ground cover plants (such as Dichondra), to assist in weed control, to reduce soil erosion and to provide localized cooling.

An analysis of land value conducted using the LER measure yielded a value of 1.674, indicating an increase in land value of 67.5%. We conclude that where land which is used for PV facilities is also suitable for agriculture, planting can provide substantial economic benefit both by increasing the yield of electricity and by providing a cash crop.

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Tables and Figures

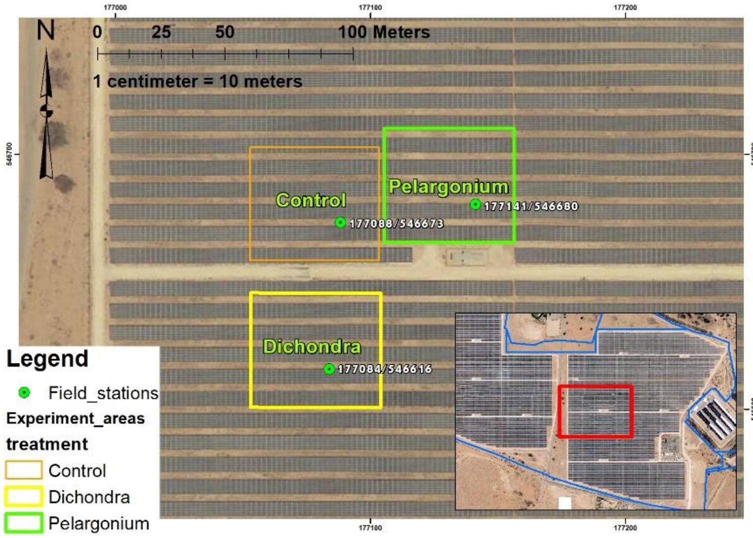

Figure 1: Three plots selected for the experiment.

Figure 2: Ploughing the site in preparation of planting seedlings.

Figure 3: The site after vegetation growth.

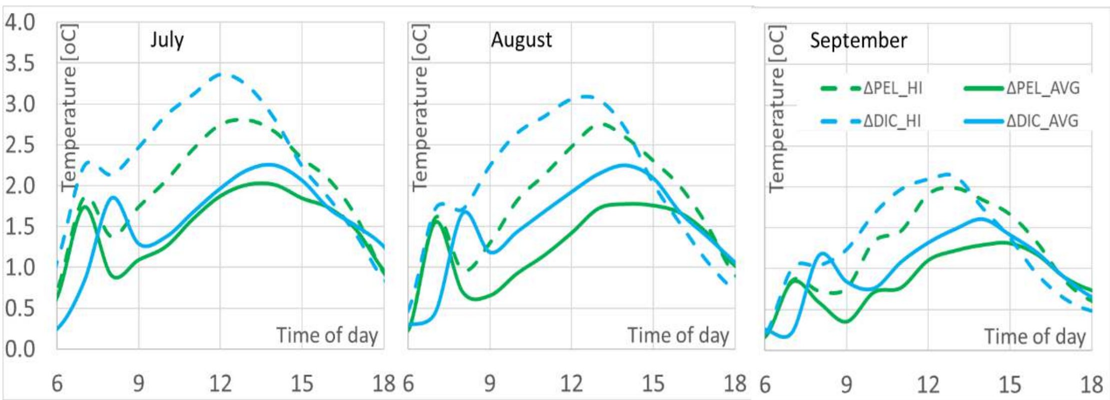

Figure 4: The difference in average monthly temperature (July, August, September) between the control and planted plots for all panels (solid line) and the highest panels on each row (dotted line)